

Small-Packaged System O&M

Learn from these all-too-common mistakes

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Editor's note: The New Buildings Institute (NBI) is conducting a Public Interest Energy Research (PIER) project for the California Energy Commission (CEC). NBI's project is called Integrated Energy Systems - Productivity and Buildings Science Program. As the name suggests, it is not individual building components, equipment or materials that optimize energy efficiency. Instead, energy efficiency is improved through the integrated design, construction and operation of building systems. One element of the overall project is examining integrated design of small HVAC systems in commercial buildings (specifically packaged rooftop units). This is the third article in a four-part series. It is based on the CEC research specific to operations and maintenance issues.

New Building Institute (NBI) researchers inspected a total of 140 packaged rooftop units and tested for them for proper operation in an attempt to identify problems that frequently occur.

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PHOTO A. It is not unusual to find the area under the rooftop access ladder used for storage.

LOCATION, LOCATION, LOCATION

Like real estate, location can mean a lot when it comes to HVAC maintenance. Maintenance of packaged rooftop units is often difficult due to the fact they are on the roof. Typical access is by a vertical ladder and roof hatch, which does not foster frequent inspections, as seen in Photo A. Contrast this with a mechanical room located just off a corridor, and it is easy to understand that rooftop units are prone to neglect. Many simple maintenance activities (e.g., checking filters, controls, belts, etc.) can be a significant effort that might otherwise be done in a more casual manner.

Packaged rooftop units are generally designed for a shorter service life than built-up HVAC equipment. They are also exposed to the weather elements that can be stressful to the equipment operation. Both can contribute to more frequent maintenance needs. Problems tend to occur during periods of system stress caused by extremely hot or cold weather. This discourages timely inspection and repair. If the problems occur during wet or icy weather, maintenance and repair can actually be hazardous. Also, construction errors can make maintenance difficult, no matter what the

weather, as seen in Photo B.

Keeping these issues in mind will help you better plan the maintenance of units. A little preventive maintenance during nice weather should help optimize operation, energy use, and comfort while minimizing "surprises" during inclement weather.

ROUTINE MAINTENANCE

Regular routine maintenance is an important component of energy efficiency, comfort, and the prevention of premature equipment failure. Simple routine checks can avoid costly maintenance



PHOTO B. Construction errors can hamper any thoughts about good maintenance. Here, a condensate line was plumbed in a manner that prevented the unit access door from opening.

contractor calls to diagnose or fix simple maintenance problems. A few standard maintenance items include:

- ☐ Check fan belts for tension and wear.
- ☐ Check filters.
- ☐ Check economizer damper linkage/movement.
- ☐ Check refrigerant, both site glass and refrigerant charge.
- ☐ Lubricate moving parts including dampers and linkage.
- ☐ Check access panels for tight fit.
- ☐ Inspect electrical wiring/connections.



PHOTO C. *Get your money's worth from your maintenance contract. This contractor left the job site with maintenance work incomplete.*

❑ Check coils for debris and clean as necessary.

Annual maintenance contracts are common. If you are considering one, make sure the staff has good experience. Maintenance staff in buildings with rooftop units are often underskilled with limited training and experience. Routine maintenance tasks should be placed on easy-to-use “cheat sheets.” Post lists in locations that encourage proactive maintenance. Maintenance logs for all units should be kept in a readily accessible binder. Maintenance contracts should require a log that remains on site.

MAINTENANCE HALL OF SHAME

Bad maintenance can be worse than no maintenance in some situations. Photos C and D were taken at a newly constructed restaurant in the San Francisco Bay Area soon after a visit by the HVAC service contractor. Note the roof was littered with old, filthy filters and bent and discarded “bird screens” intended to protect the unit’s outdoor air opening. A closer inspection revealed several instances of missing filters and filthy cooling coils. This lack of regard for proper service procedures was not unique in our study. Photo E shows that a fan motor fell off its mounting and into the evaporator coil. Although refrigerant wasn’t lost, there was no airflow. Comfort complaints that went on for weeks were blamed on a thermostat problem. A simple check of the system would have re-

vealed this problem much earlier.

A less obvious problem can occur when well-meaning but improper maintenance procedures are employed. A recent study conducted in California indicated that over half of the units tested were either over or undercharged, with an average energy penalty on the order of 10 percent of the annual cooling costs. Adding refrigerant until the suction line is “beer-can cold,” rather than following more rigorous procedures, can impact comfort and energy efficiency. This is likely due to inadequate staff training, experience, or time allocated for the procedure.

CONTROLS

Controls maintenance is key in terms of long term operating efficiency of any HVAC system. In this respect, rooftop systems are really not much different than other systems. Although rooftop HVAC controls are relatively simple, they are no less important. Controls that should receive the most attention are the thermostat and the economizer. From a maintenance standpoint, they are subject to failure or changes that can result in higher energy consumption and/or reduced comfort.

The economizer or control damper motor and linkage are key components of most packaged system energy efficiency controls. Our research found that 70 percent of the economizers in rooftop HVAC units do not work. Reasons include: stuck/bent damper blades, loose or disconnected linkages, or loose wiring on about two-thirds of the units and failure of the controller on the remaining units.

One way to check the damper and operation is to start with a simple physical inspection of the linkage. Check to see if the linkage is damaged or disconnected. When the system is turned off, the ventilation damper should close, and the re-

turn air damper should be fully open. When you turn the unit back on, the damper should stroke to its minimum position. Also, check the damper movement by adjusting the minimum outdoor-air-position setting on the econo-



PHOTO D. *A dirty evaporator coil on a rooftop system.*

mizer controller over its full range. Look for smooth, steady movement of the damper and linkage. A check of the economizer controller and sensors can be done by simulating conditions under which the economizer should operate. Researchers in our study used a can of cold spray to cool off the outdoor-air sensor while the unit was in cooling mode and observed economizer operation.

Another control issue is proper thermostat operation. You may frequently find altered programs in thermostats. Lockboxes help prevent unauthorized tampering. Some thermostats have electronic access codes that allow minor temperature adjustments, but no schedule changes. These maximize savings while allowing some occupant control. You should know how to program and check the thermostat. This will maximize energy efficiency and minimize comfort complaints. Lockboxes tend to create occupant attitudes of “us versus them,” so you should make an effort to find out if occupants are comfortable. The thermostat should be programmed so that the fan runs continuously during the occu-



PHOTO E. This fan motor fell off its mounting and into the evaporator coil.

period to provide adequate ventilation.

OCCUPANTS AND COMFORT

One important aspect of ongoing system operation and maintenance is getting feedback from the occupants. If occupants are uncomfortable or frequently feel the need to adjust the thermostat, this can be a good indicator that there are problems with the system, as illustrated in Photo F.

While occasional comfort complaints are normal, widespread consistent complaints by many occupants usually indicate a real problem with the system or its operation. If you listen to all of the occupants carefully, you can often accurately assess the situation. Changes in thermostat setpoints should be made carefully and in small increments of a degree or two. Radical thermostat adjustments don't necessarily improve the HVAC system response, and may confound efforts

to troubleshoot problems.

Comfort complaints aren't always just a thermostat setpoint problem. Unusually cold supply air may mean the supply fan airflow is too low. Poor airflow may be an indicator of a disconnected, collapsed, or excessive flex duct. It can also mean plugged filters or a loose fan belt.

You can survey the occupants to begin to pinpoint what comfort problems are frequent and which are just occasional. You can also use the survey to pinpoint problem locations. For example, if people frequently complain about the same space, maybe there is a unique problem associated with that space.

Remember to check comfort throughout the year. Problems can be widely different in the spring/fall, summer, and winter.



PHOTO F. A common example of occupant manipulation of the HVAC system to solve a comfort problem.

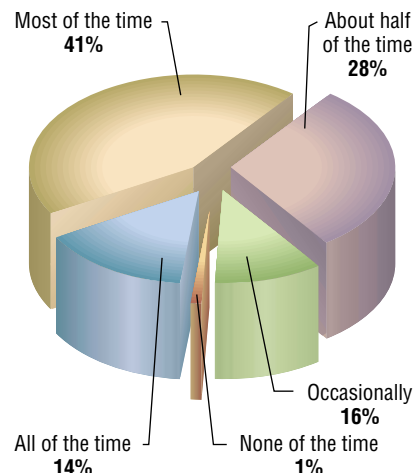


FIGURE 1. How much of the time are you comfortable? Results of the PIER project comfort survey. About 55 percent of the respondents were comfortable all or most of the time. Many of the O&M problems observed do not affect comfort, but have an impact on energy efficiency.

SUMMARY

Proper operation and maintenance of small packaged cooling systems plays an important role in maintaining occupant comfort, indoor-air quality, and energy efficiency. Check thermostat setpoint and fan control modes frequently to correct problems due to occupant tampering. Be sure to maintain the equipment using approved maintenance procedures, and shop wisely when looking for an HVAC service contractor to maintain the units.